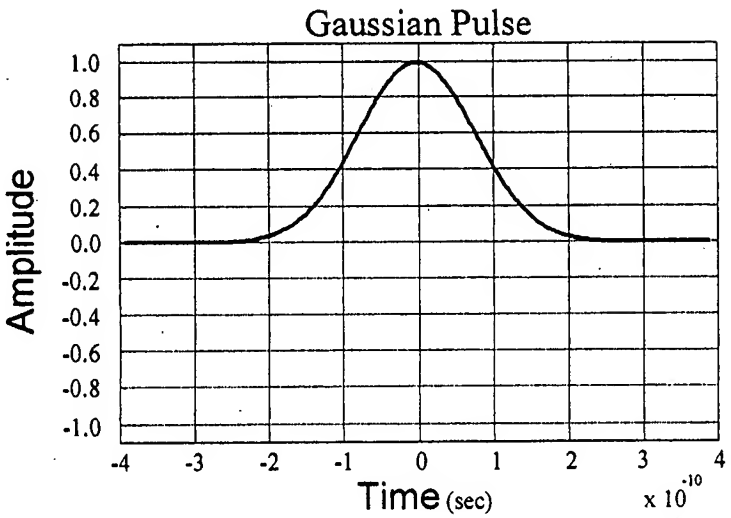


FIG. 1A

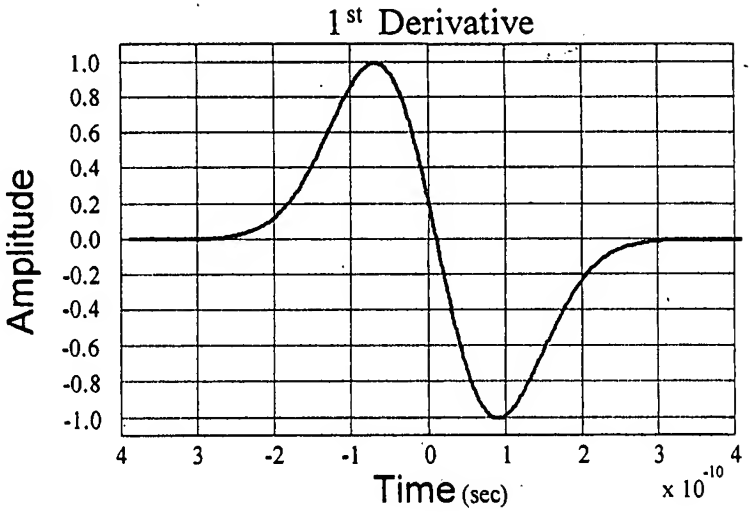


FIG. 1B

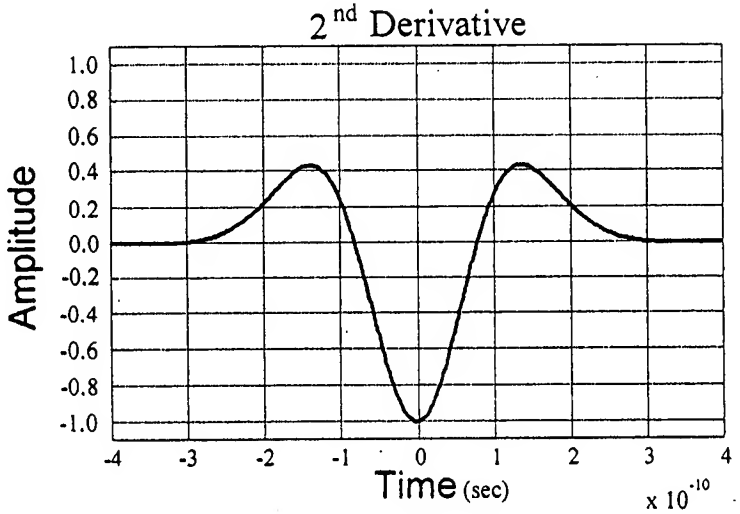


FIG. 1C

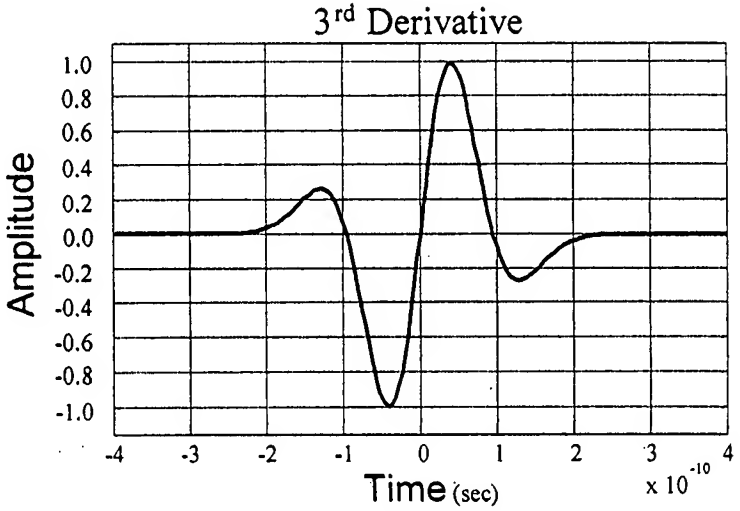


FIG. 1D

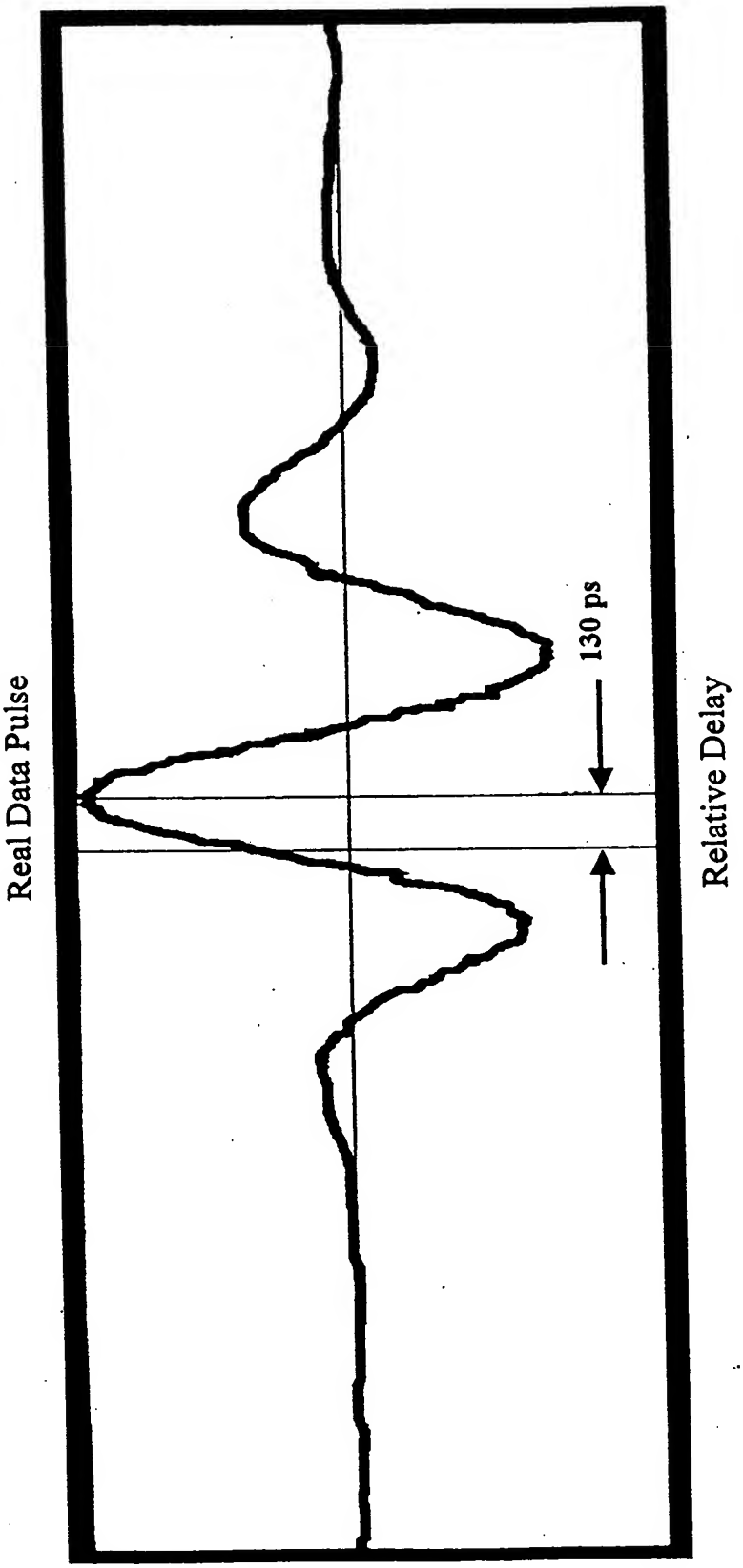


FIG. 1E

BEST AVAILABLE COPY

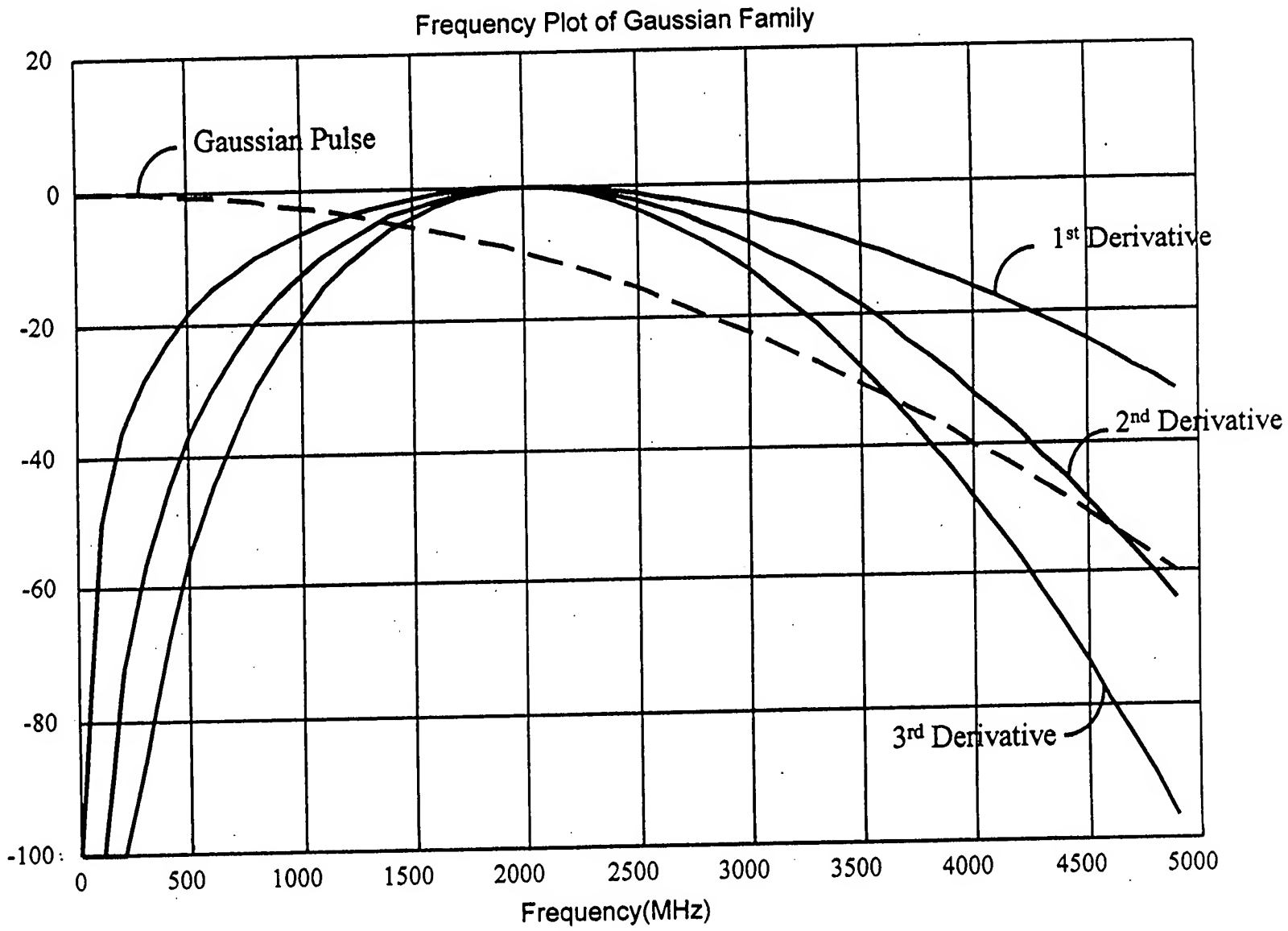

Frequency Plot of Gaussian Family
20
0
-20
-40
-60
-80
-100
Gaussian Pulse
1st Derivative
2nd Derivative
3rd Derivative
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Frequency(MHz)

FIG. 1F

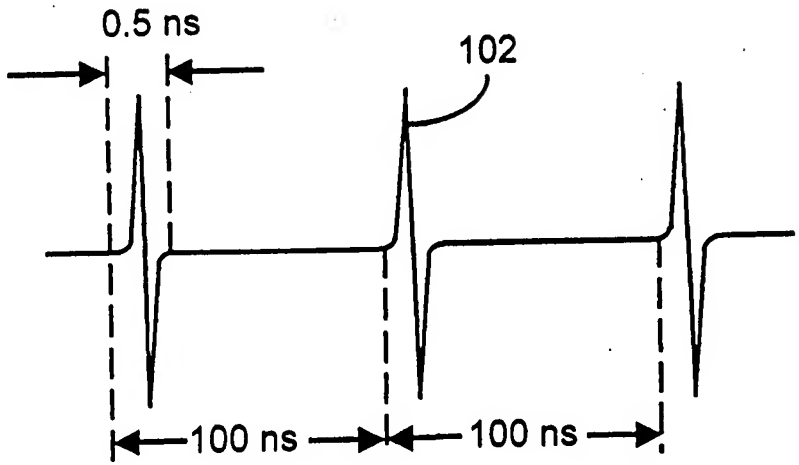


FIG. 2A

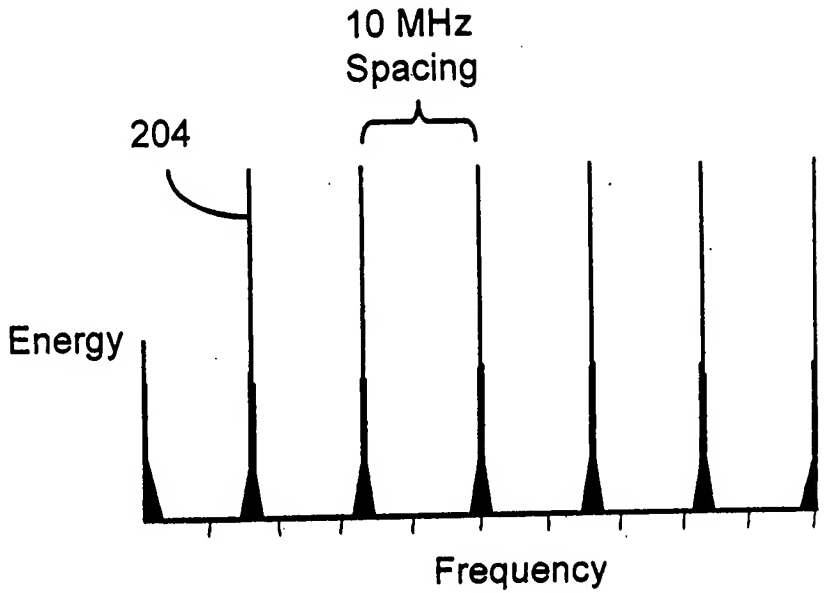


FIG. 2B

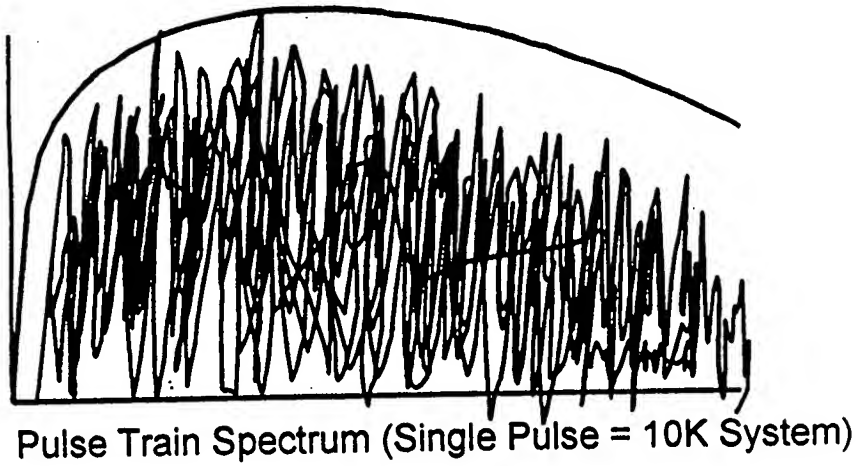


FIG. 2C

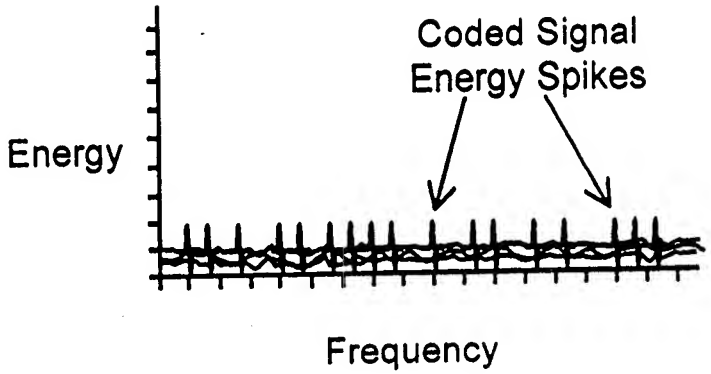


FIG. 2D

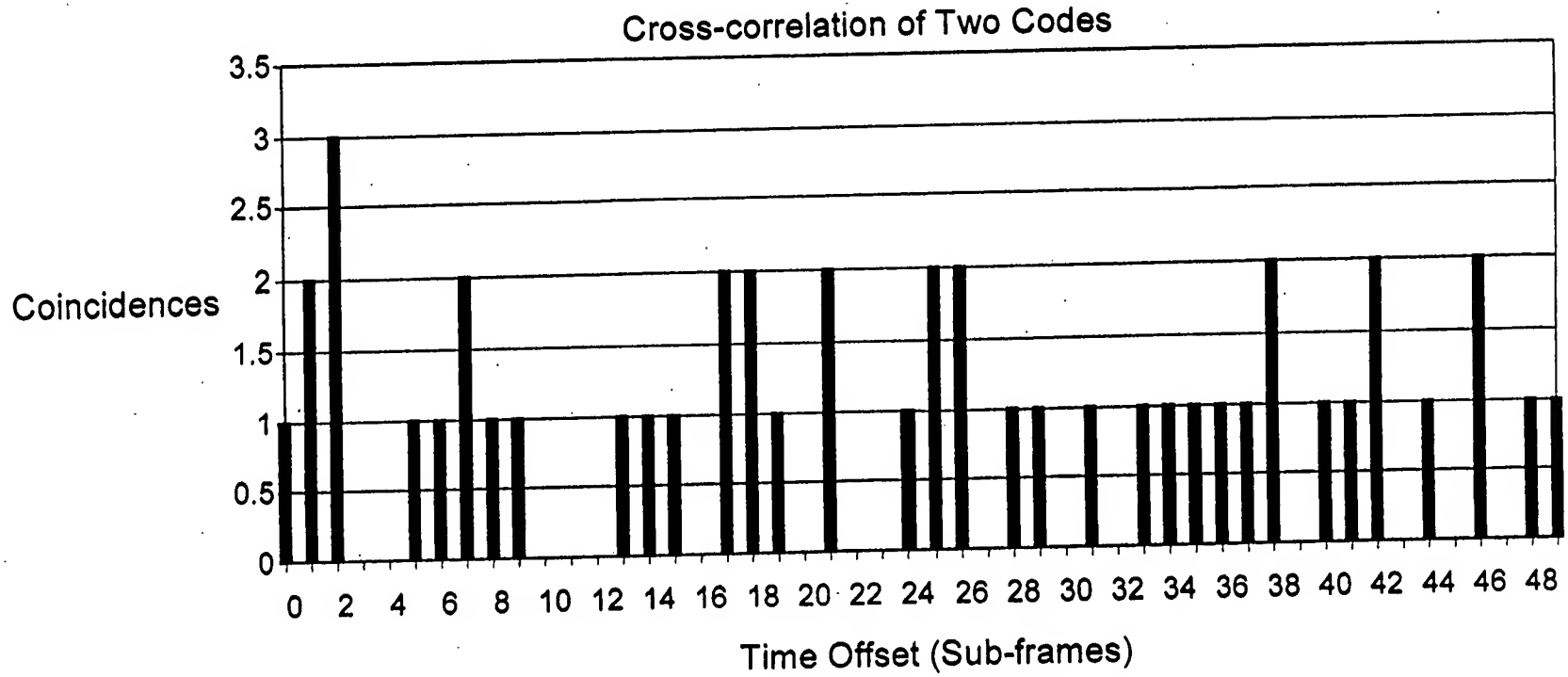
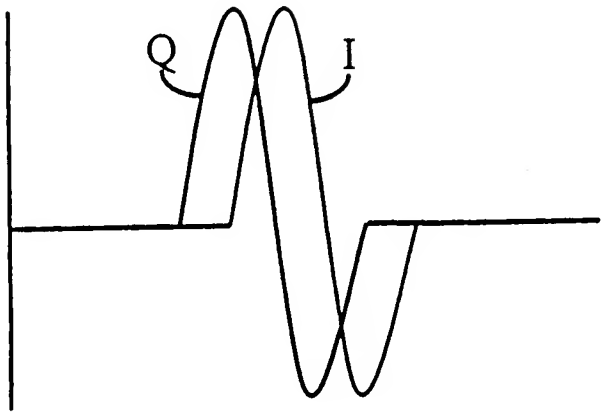
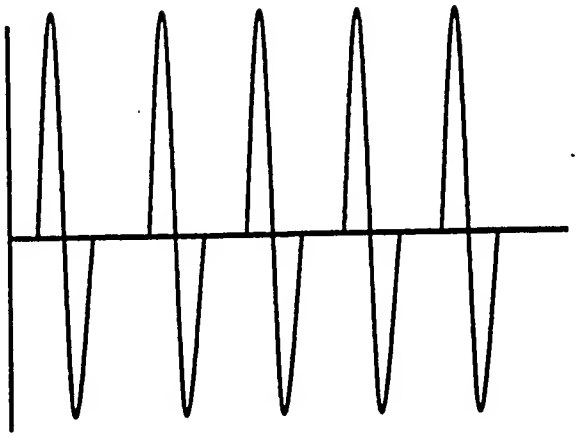

Cross-correlation of Two Codes
Coincidences
3.5
3
2.5
2
1.5
1
0.5
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48
Time Offset (Sub-frames)

FIG. 3



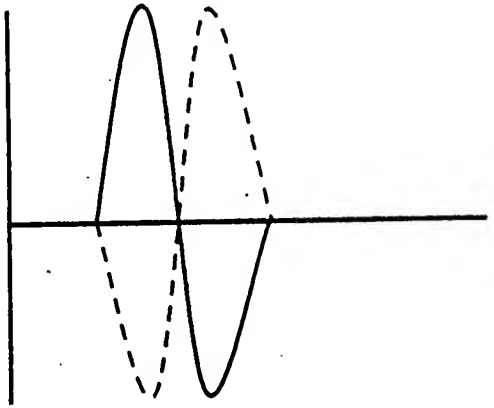
Early – Late Modulation

FIG. 4A



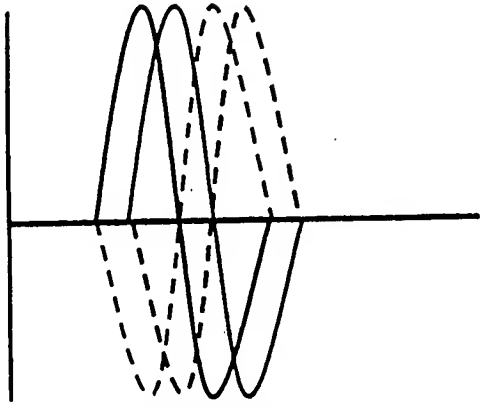
One of Many Modulation

FIG. 4B



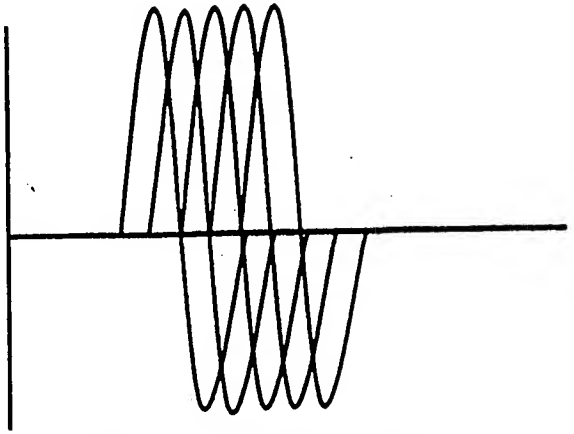
Flip Modulation

FIG. 4C



Quad Flip Modulation

FIG. 4D



Vector Modulation

FIG. 4E

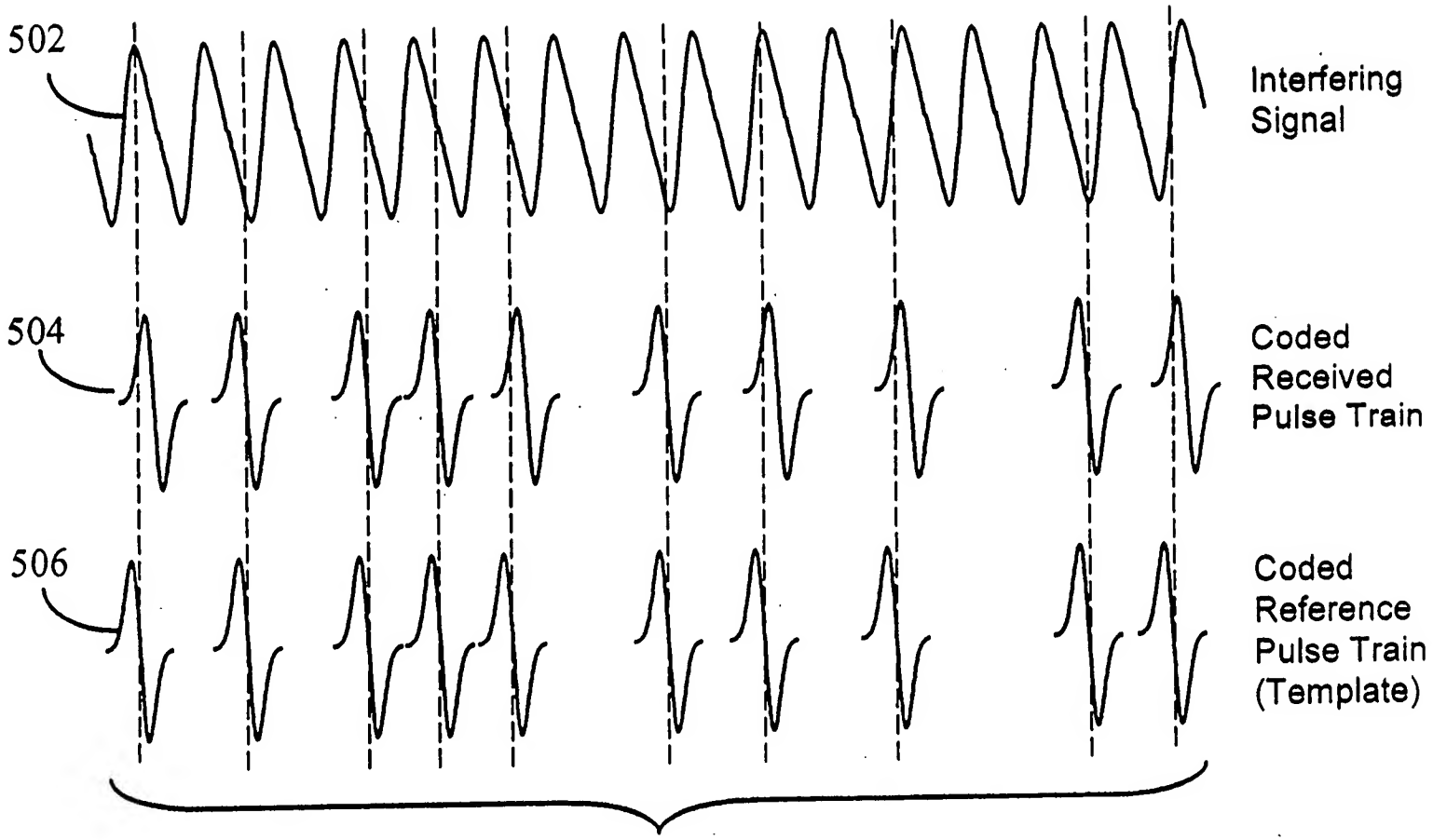

502
Interfering Signal
504
Coded Received Pulse Train
506
Coded Reference Pulse Train (Template)

FIG. 5A

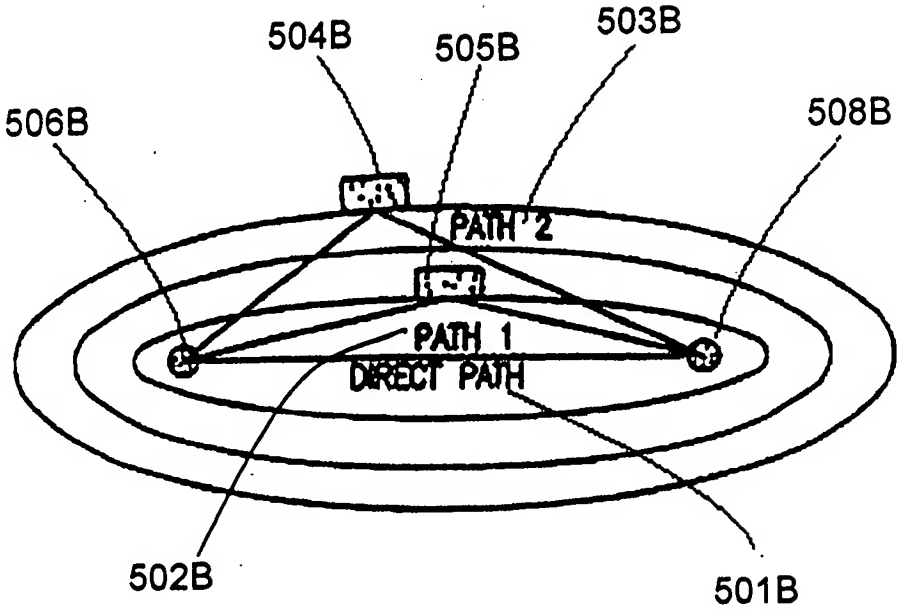

504B
505B
503B
506B
508B
PATH 2
PATH 1
DIRECT PATH
502B
501B

FIG. 5B

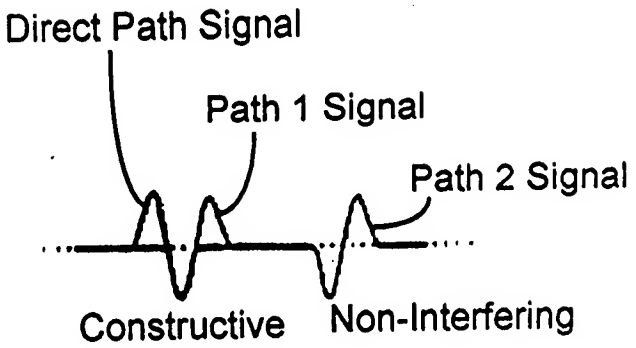

Direct Path Signal
Path 1 Signal
Path 2 Signal
Constructive
Non-Interfering

FIG. 5C

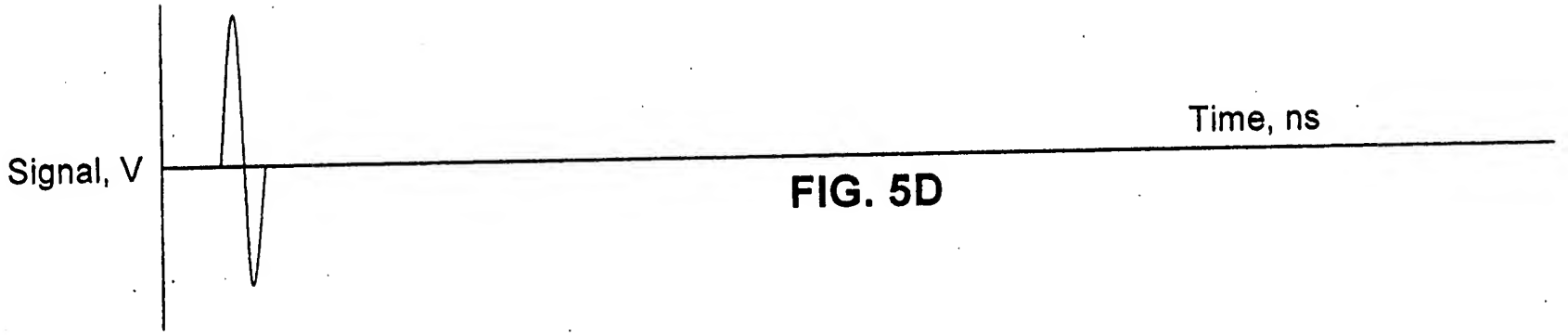


FIG. 5D

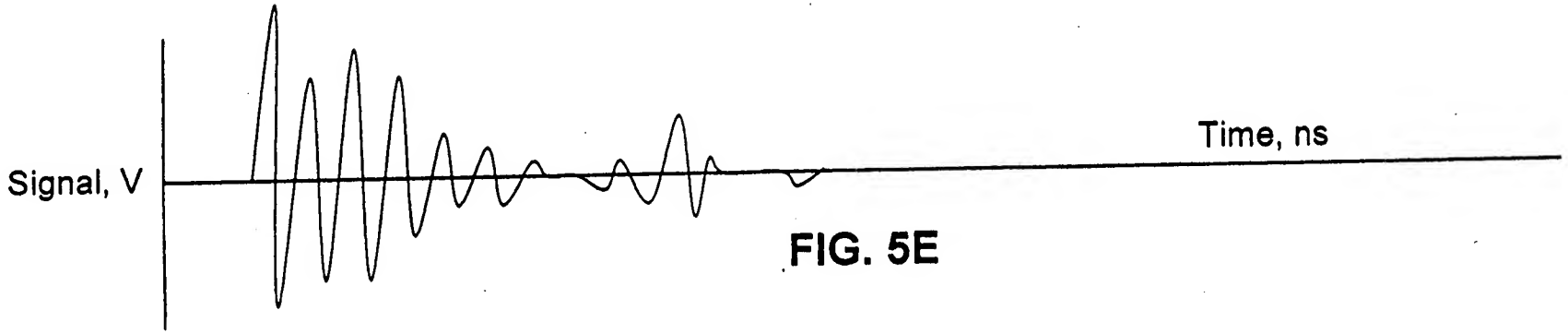


FIG. 5E

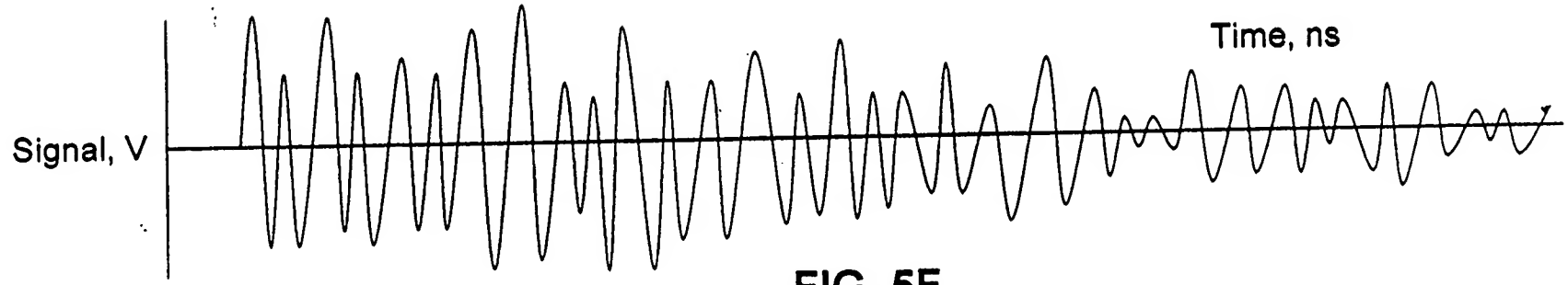


FIG. 5F

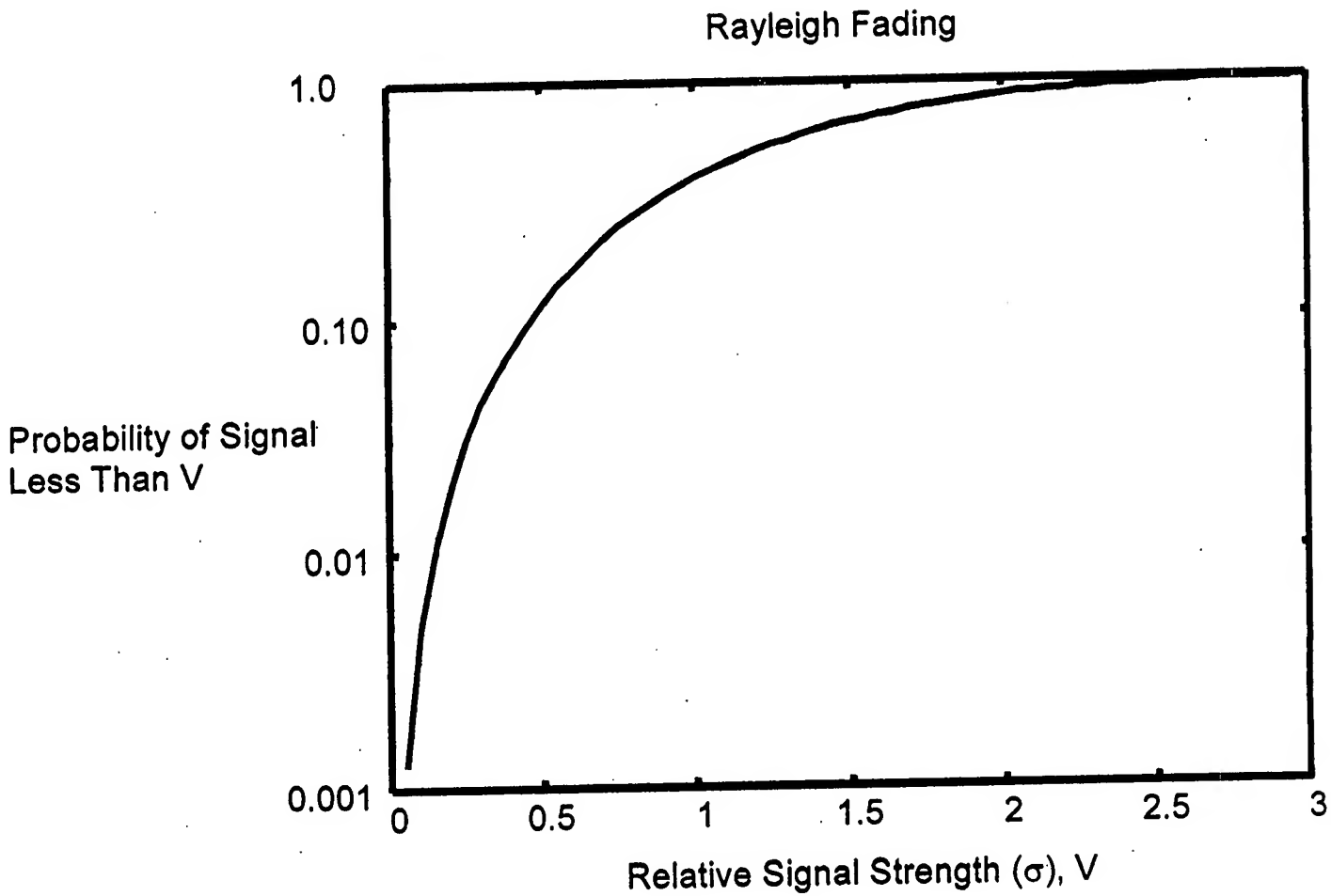

Rayleigh Fading
1.0
0.10
0.01
0.001
Probability of Signal
Less Than V
0
0.5
1
1.5
2
2.5
3
Relative Signal Strength (σ), V

Fig. 5G

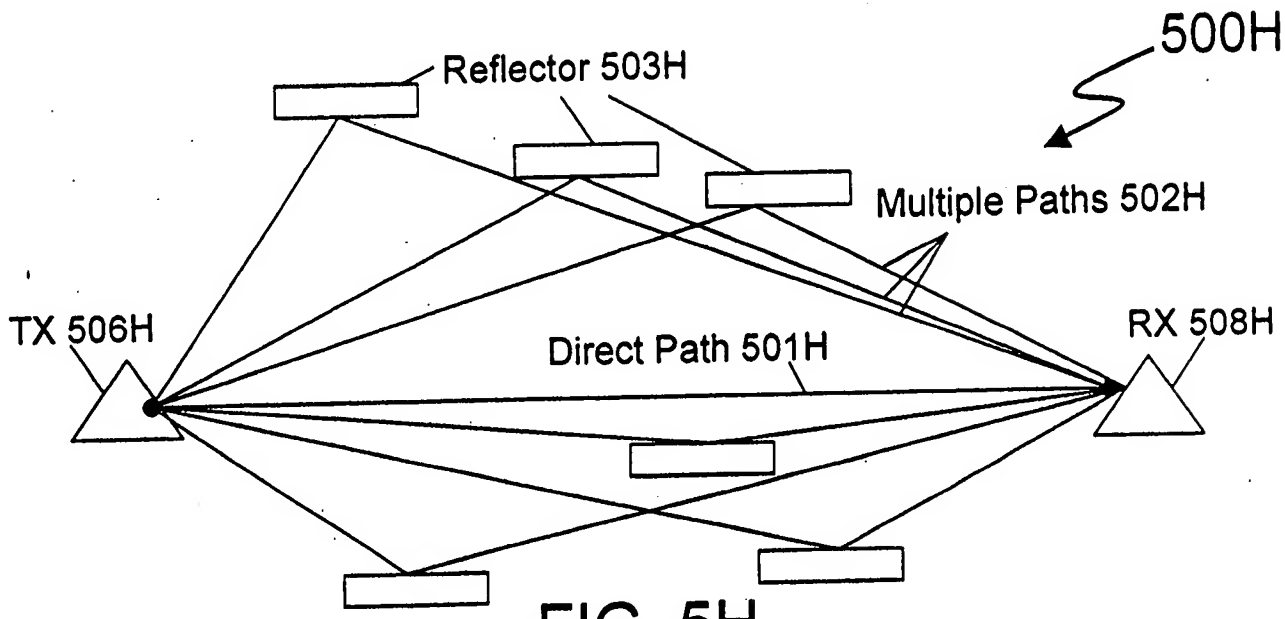

500H
Reflector 503H
Multiple Paths 502H
TX 506H
Direct Path 501H
RX 508H

FIG. 5H

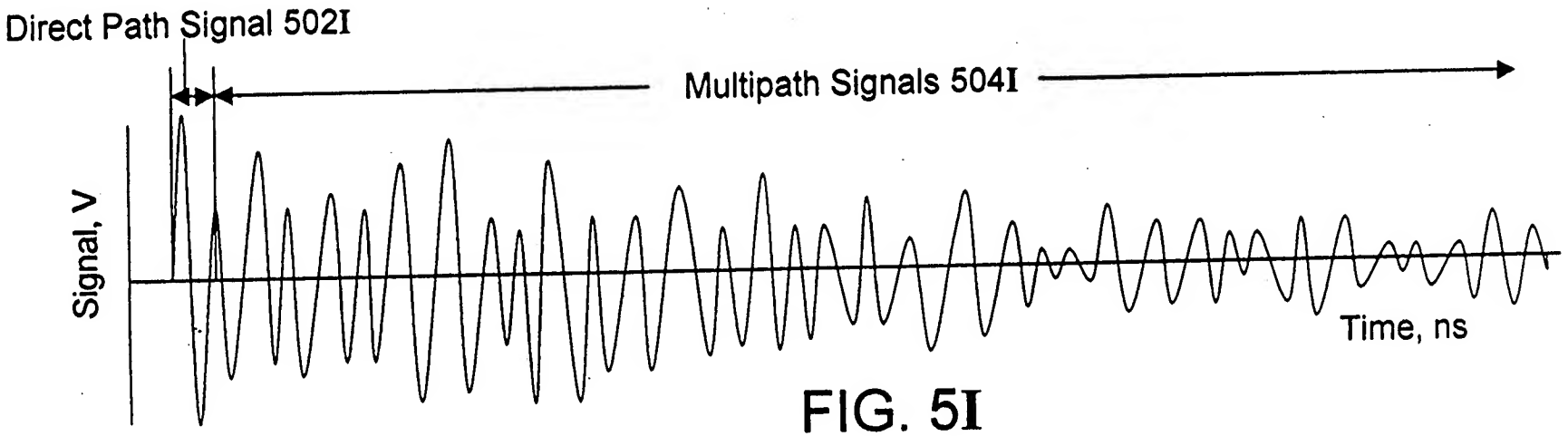

Direct Path Signal 502I
Multipath Signals 504I
Signal, V
Time, ns

FIG. 5I

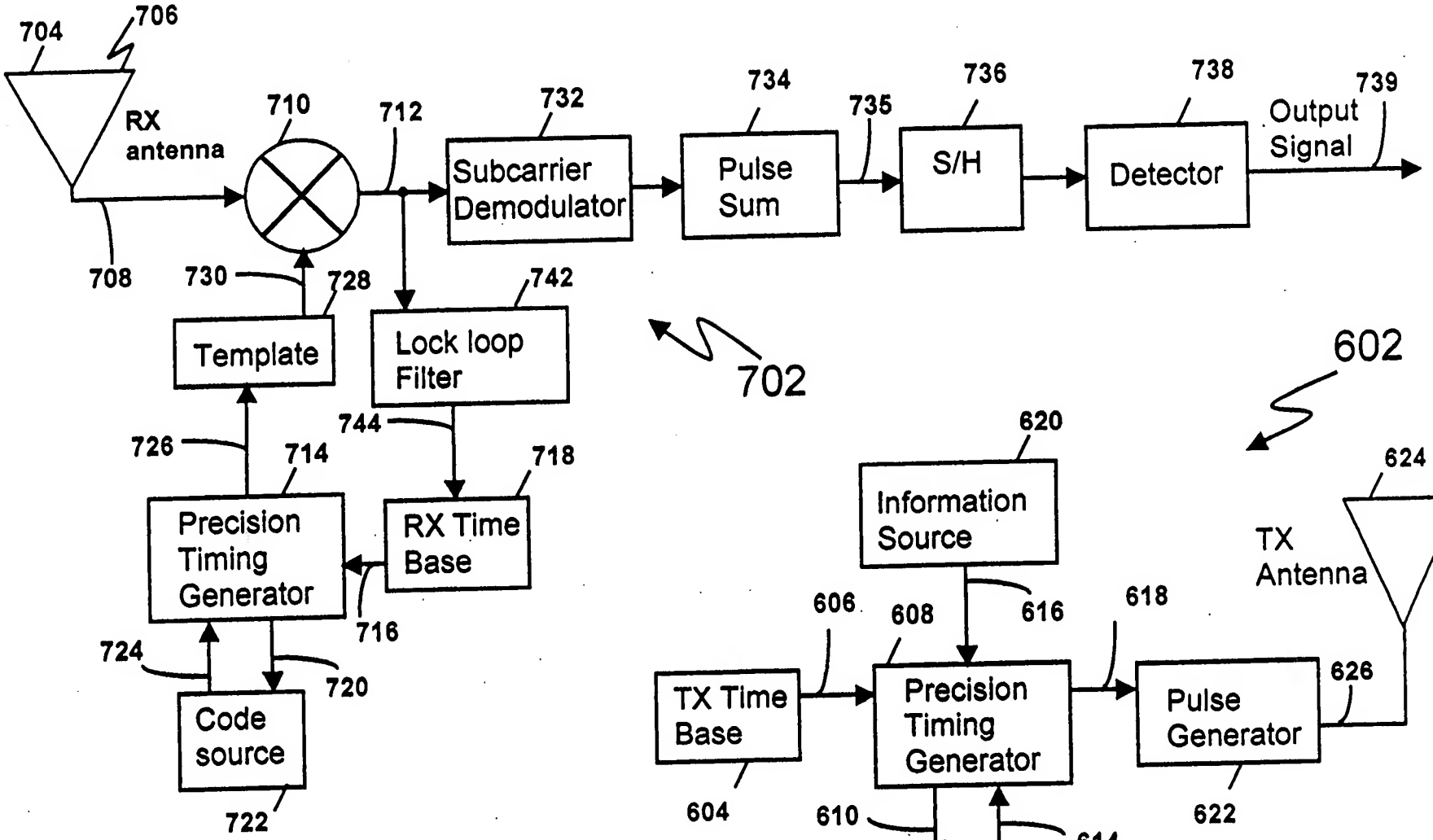

704
706
RX antenna
710
712
732
734
735
736
738
739
Output Signal
Subcarrier Demodulator
Pulse Sum
S/H
Detector
708
730
728
742
Template
Lock loop Filter
702
726
744
714
718
Precision Timing Generator
RX Time Base
716
724
720
Code source
722

FIG. 7

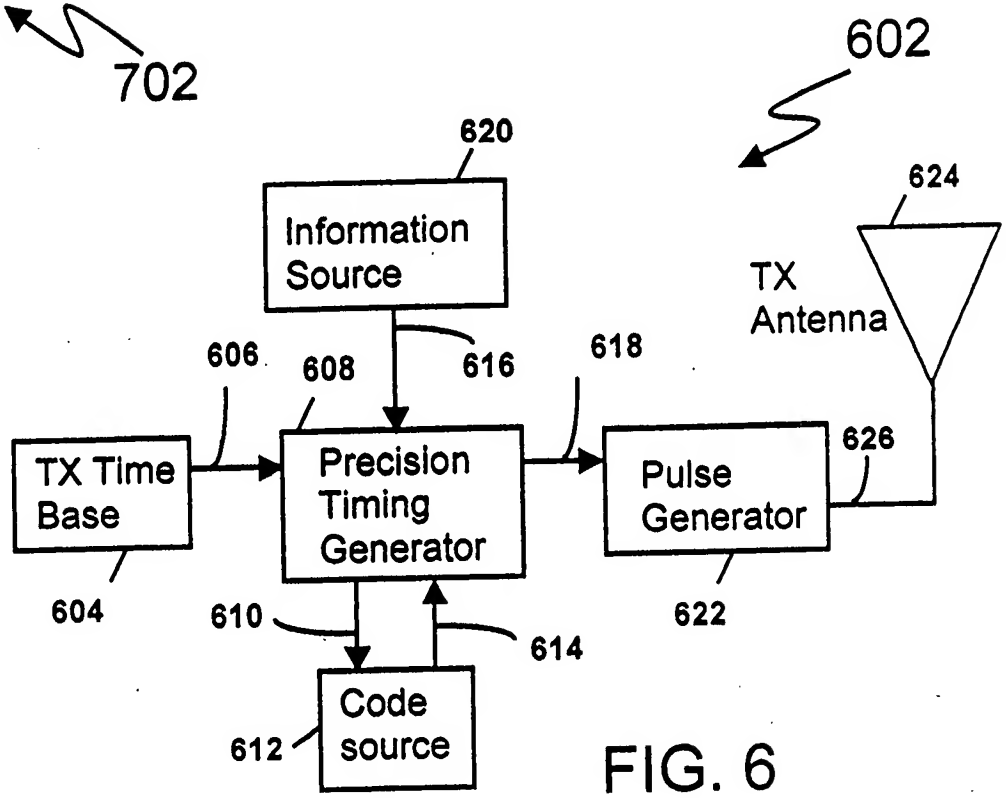

602
620
624
Information Source
TX Antenna
606
608
616
618
TX Time Base
Precision Timing Generator
Pulse Generator
626
604
610
614
622
Code source
612

FIG. 6

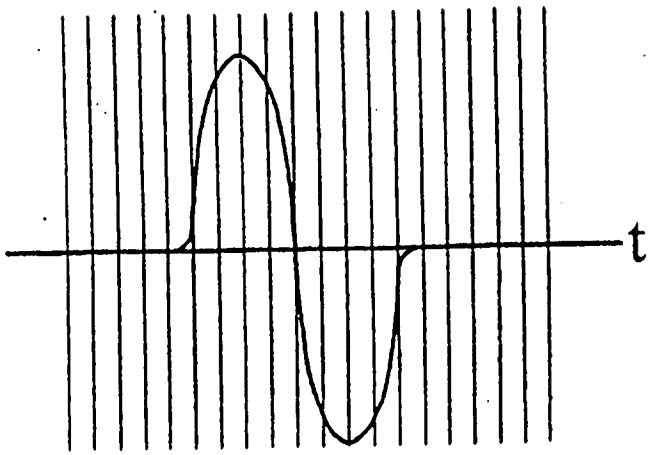


FIG. 8A

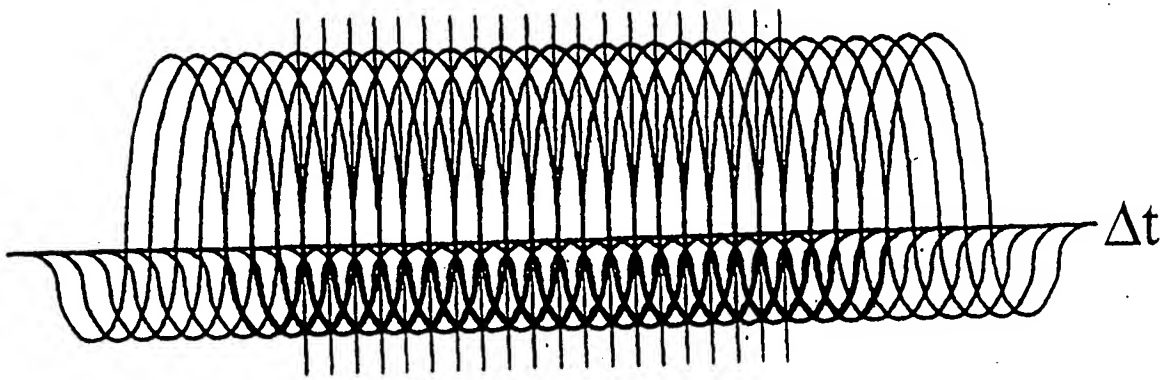


FIG. 8B

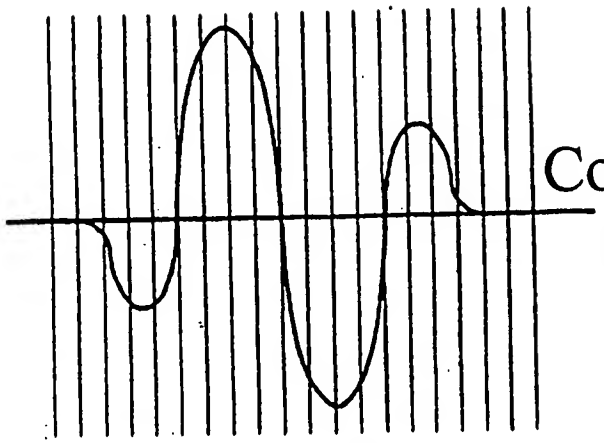


FIG. 8C

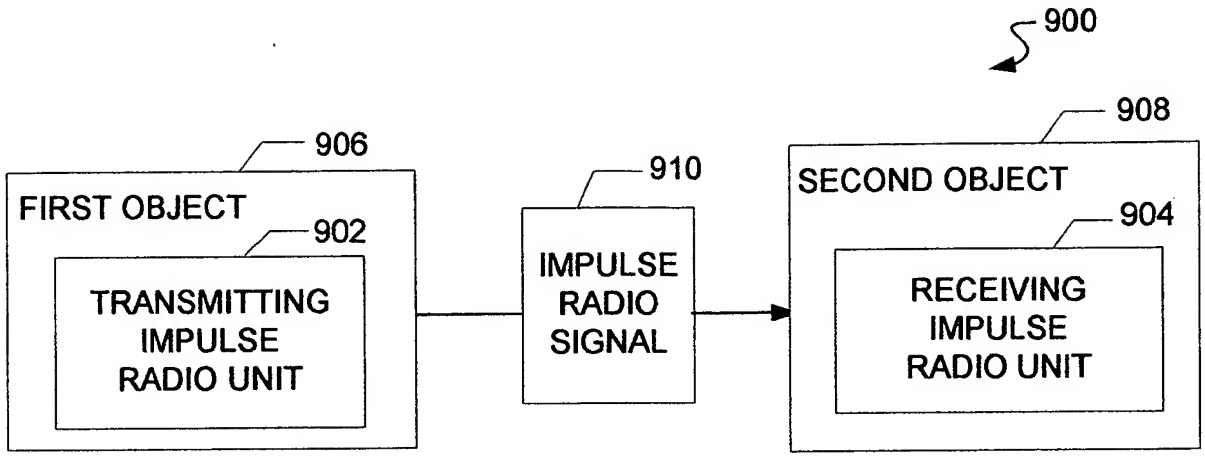

900
908
906
910
FIRST OBJECT
902
SECOND OBJECT
904
TRANSMITTING IMPULSE RADIO UNIT
IMPULSE RADIO SIGNAL
RECEIVING IMPULSE RADIO UNIT

FIG. 9

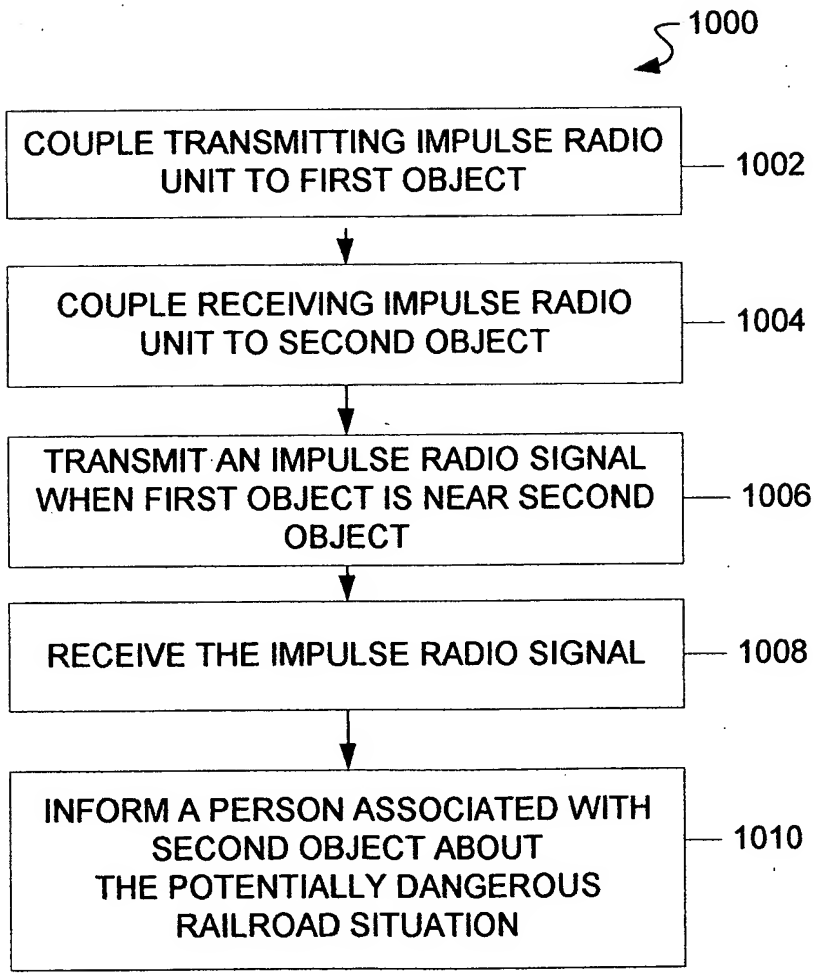

1000
COUPLE TRANSMITTING IMPULSE RADIO UNIT TO FIRST OBJECT
1002
COUPLE RECEIVING IMPULSE RADIO UNIT TO SECOND OBJECT
1004
TRANSMIT AN IMPULSE RADIO SIGNAL WHEN FIRST OBJECT IS NEAR SECOND OBJECT
1006
RECEIVE THE IMPULSE RADIO SIGNAL
1008
INFORM A PERSON ASSOCIATED WITH SECOND OBJECT ABOUT THE POTENTIALLY DANGEROUS RAILROAD SITUATION
1010

FIG. 10

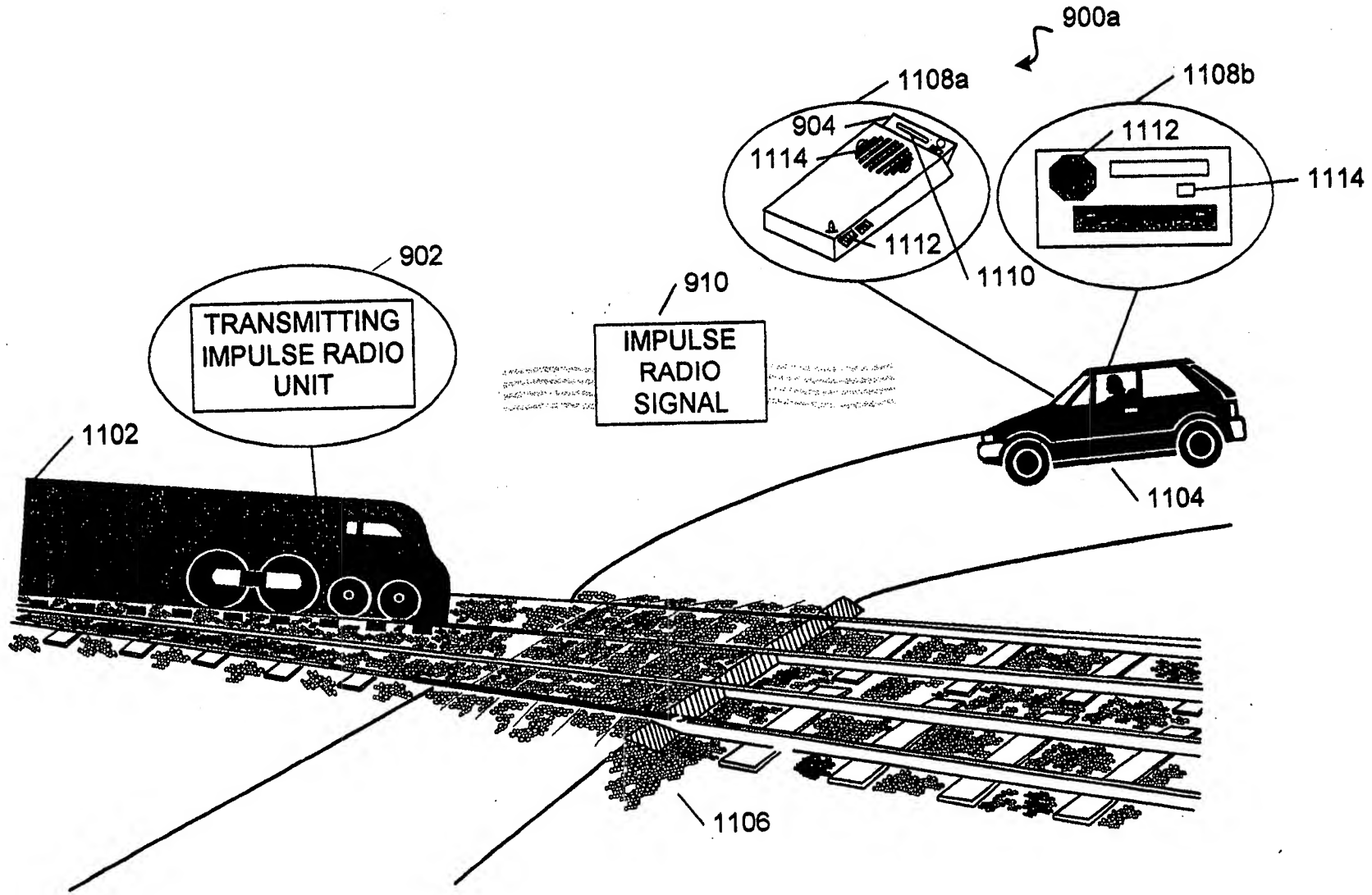

900a
1108a
1108b
904
1114
1112
1110
1112
1114
902
910
TRANSMITTING IMPULSE RADIO UNIT
IMPULSE RADIO SIGNAL
1102
1104
1106

FIG. 11

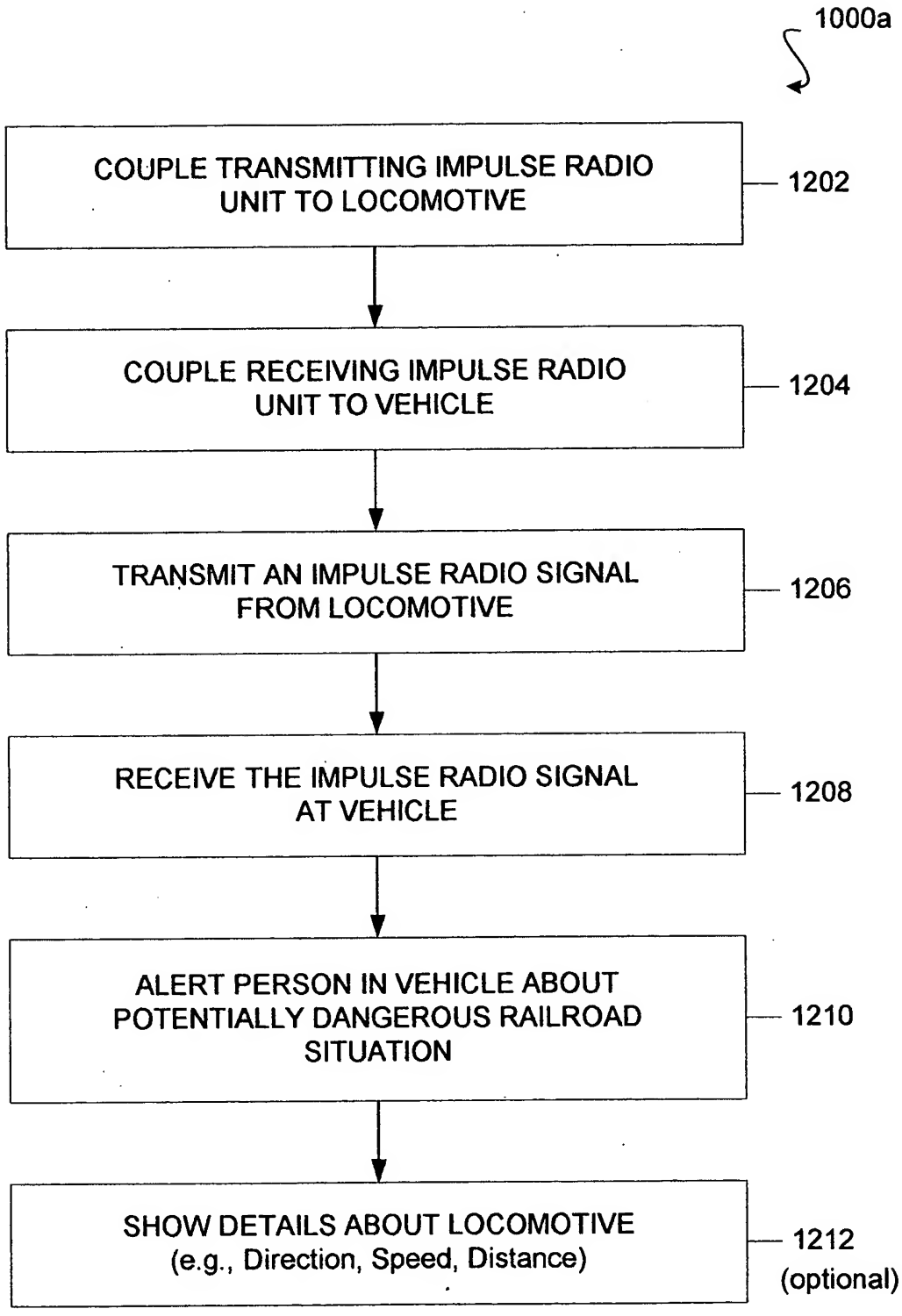

1000a
COUPLE TRANSMITTING IMPULSE RADIO UNIT TO LOCOMOTIVE
1202
COUPLE RECEIVING IMPULSE RADIO UNIT TO VEHICLE
1204
TRANSMIT AN IMPULSE RADIO SIGNAL FROM LOCOMOTIVE
1206
RECEIVE THE IMPULSE RADIO SIGNAL AT VEHICLE
1208
ALERT PERSON IN VEHICLE ABOUT POTENTIALLY DANGEROUS RAILROAD SITUATION
1210
SHOW DETAILS ABOUT LOCOMOTIVE (e.g., Direction, Speed, Distance)
1212 (optional)

FIG.12

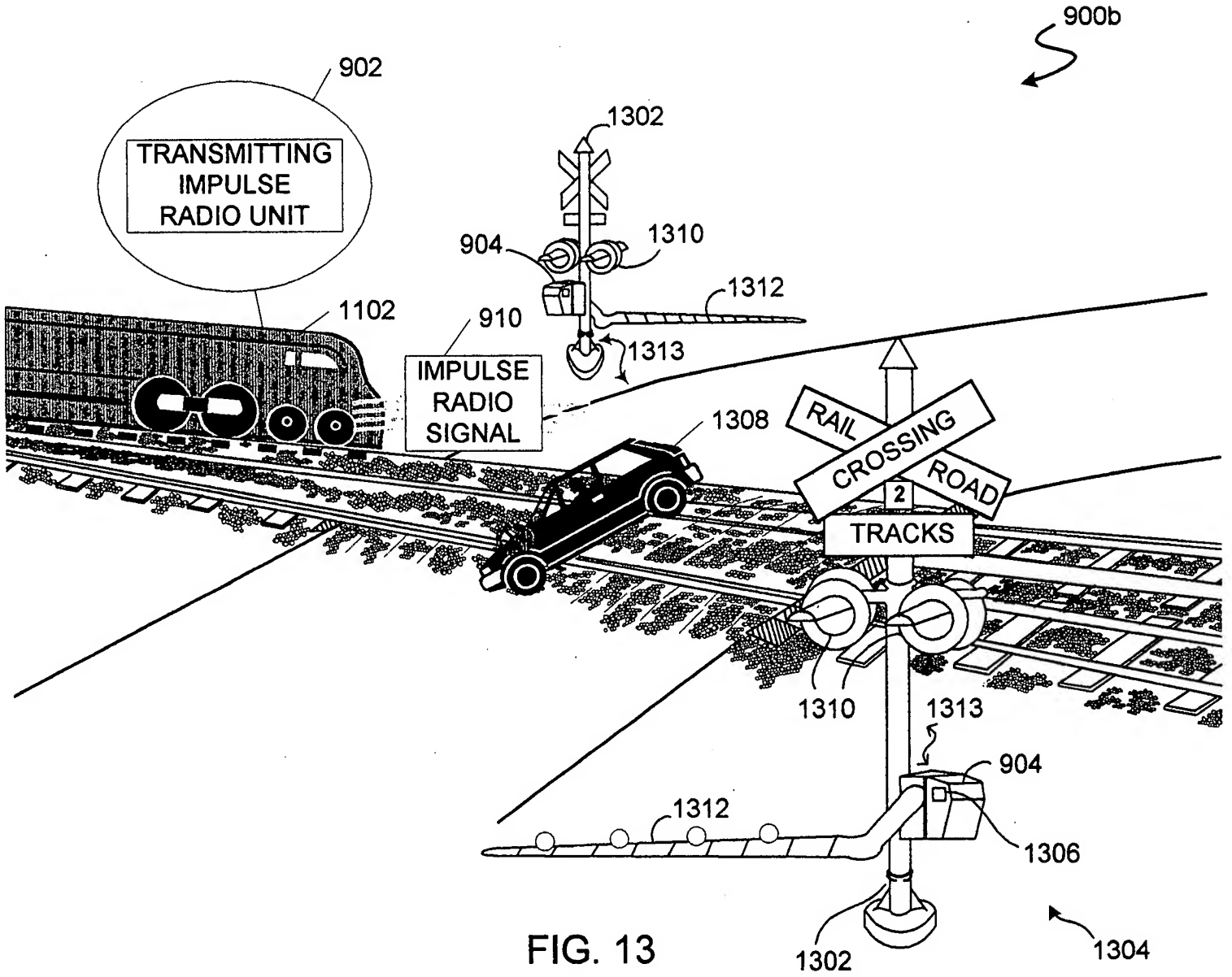

900b
902
TRANSMITTING IMPULSE RADIO UNIT
1302
904
1310
1312
1313
1102
910
IMPULSE RADIO SIGNAL
1308
RAIL
CROSSING
ROAD
2
TRACKS
1310
1313
904
1312
1306
1302
1304

FIG. 13

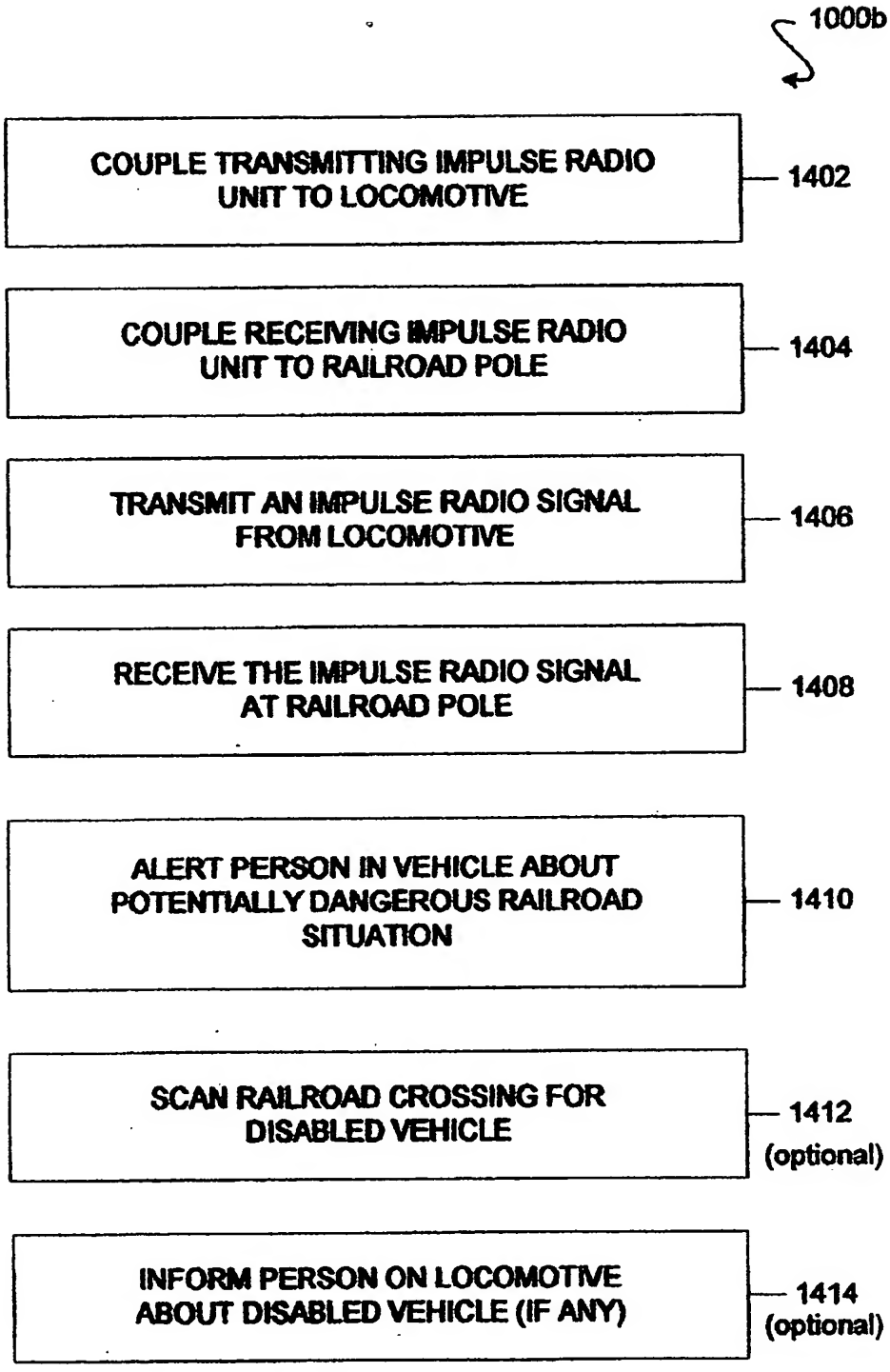

1000b
COUPLE TRANSMITTING IMPULSE RADIO UNIT TO LOCOMOTIVE
1402
COUPLE RECEIVING IMPULSE RADIO UNIT TO RAILROAD POLE
1404
TRANSMIT AN IMPULSE RADIO SIGNAL FROM LOCOMOTIVE
1406
RECEIVE THE IMPULSE RADIO SIGNAL AT RAILROAD POLE
1408
ALERT PERSON IN VEHICLE ABOUT POTENTIALLY DANGEROUS RAILROAD SITUATION
1410
SCAN RAILROAD CROSSING FOR DISABLED VEHICLE
1412
(optional)
INFORM PERSON ON LOCOMOTIVE ABOUT DISABLED VEHICLE (IF ANY)
1414
(optional)

FIG. 14

BEST AVAILABLE COPY

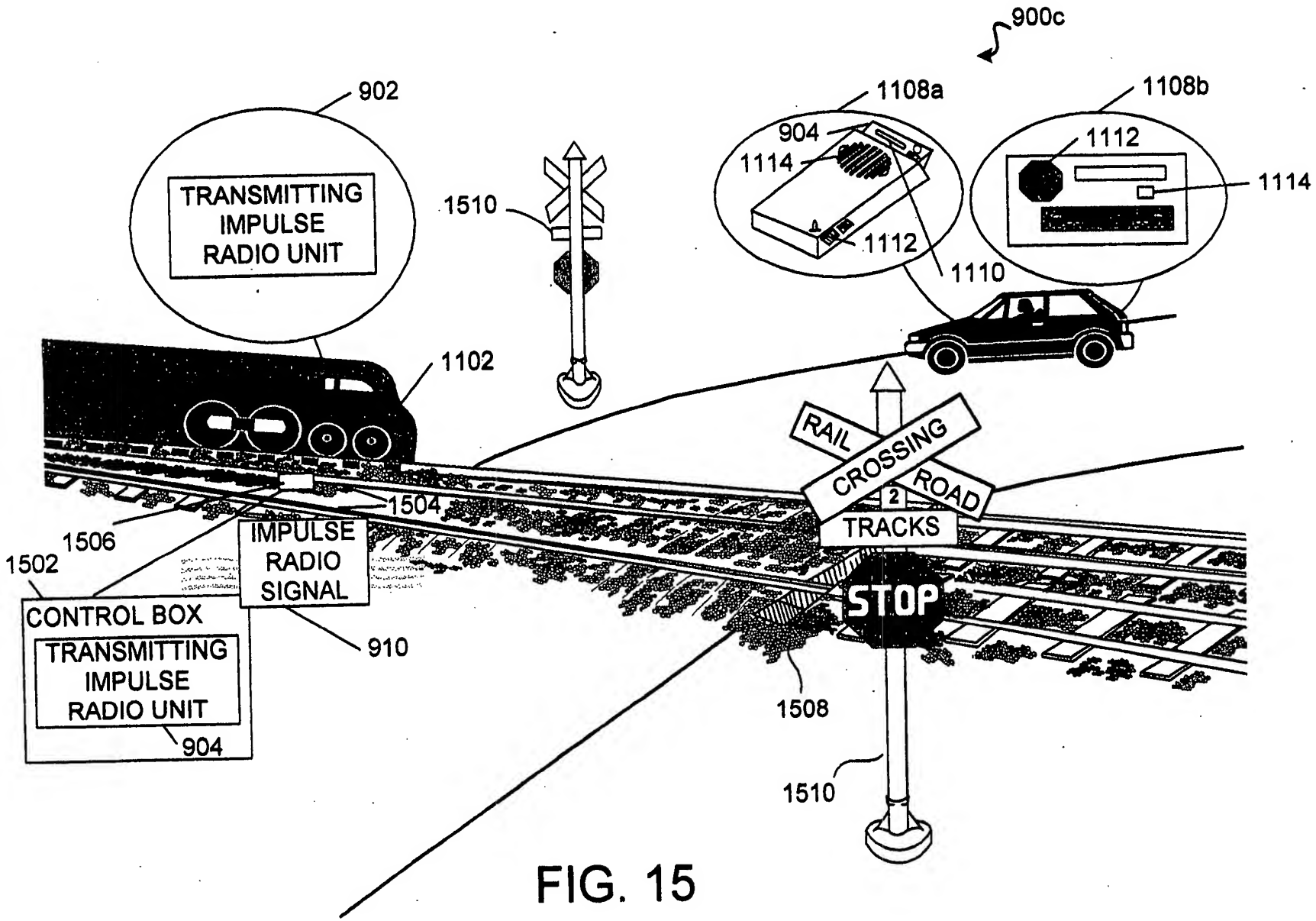


FIG. 15

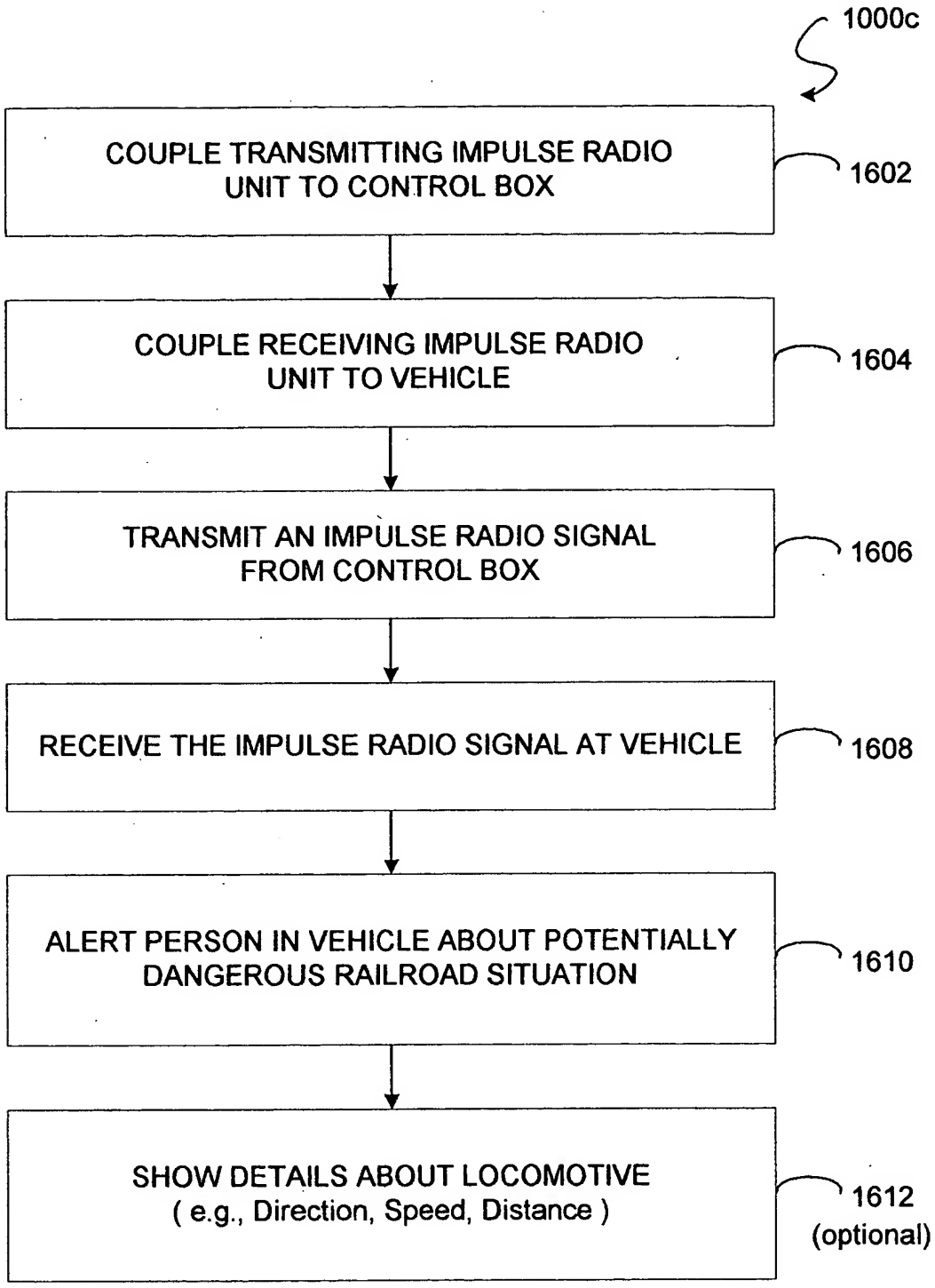

1000c
COUPLE TRANSMITTING IMPULSE RADIO UNIT TO CONTROL BOX
1602
COUPLE RECEIVING IMPULSE RADIO UNIT TO VEHICLE
1604
TRANSMIT AN IMPULSE RADIO SIGNAL FROM CONTROL BOX
1606
RECEIVE THE IMPULSE RADIO SIGNAL AT VEHICLE
1608
ALERT PERSON IN VEHICLE ABOUT POTENTIALLY DANGEROUS RAILROAD SITUATION
1610
SHOW DETAILS ABOUT LOCOMOTIVE (e.g., Direction, Speed, Distance)
1612
(optional)

FIG. 16

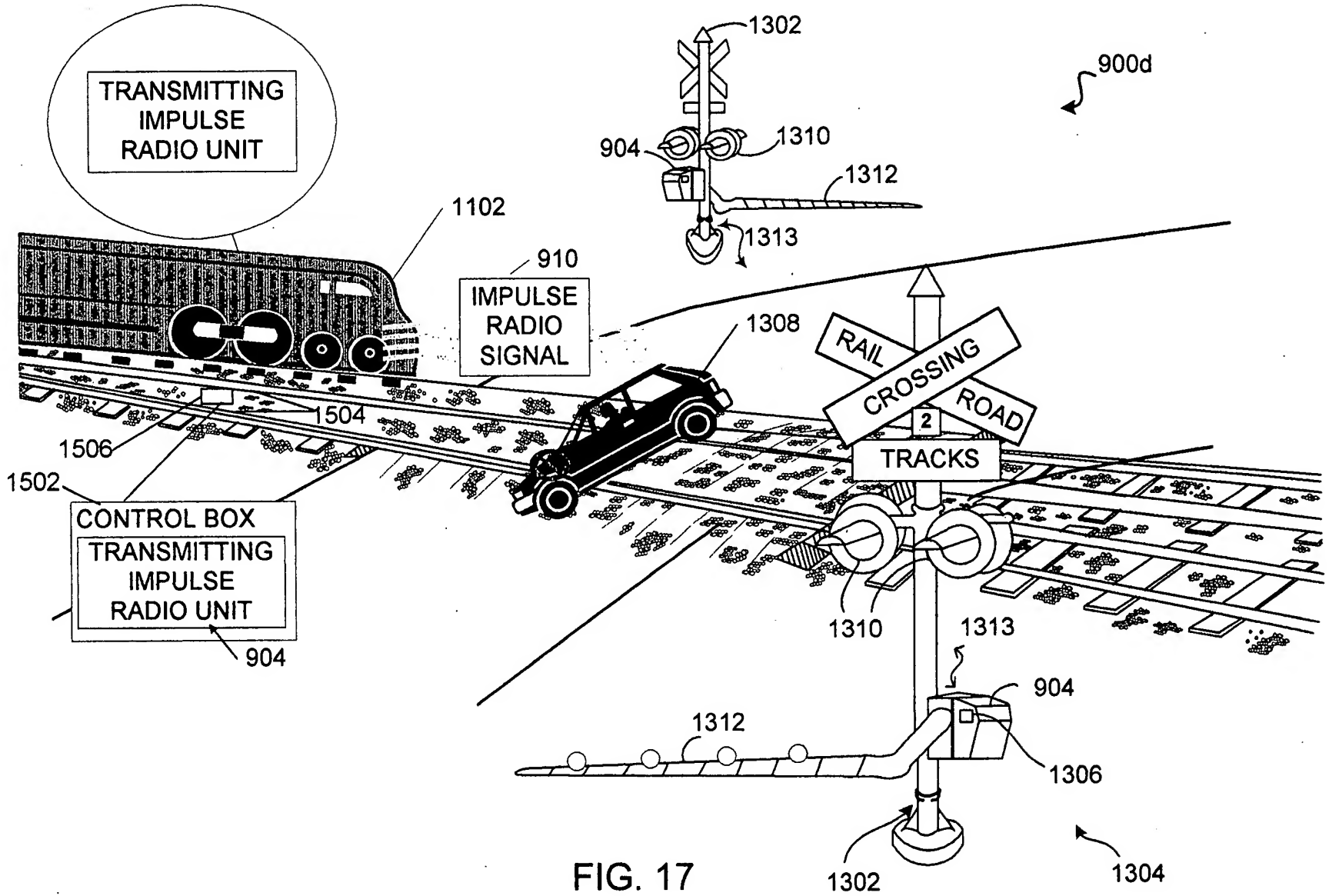

TRANSMITTING IMPULSE RADIO UNIT
1102
910
IMPULSE RADIO SIGNAL
1302
900d
904
1310
1312
1313
1308
RAIL
CROSSING
ROAD
2
TRACKS
1504
1506
1502
CONTROL BOX
TRANSMITTING IMPULSE RADIO UNIT
904
1310
1313
904
1312
1306
1302
1304

FIG. 17

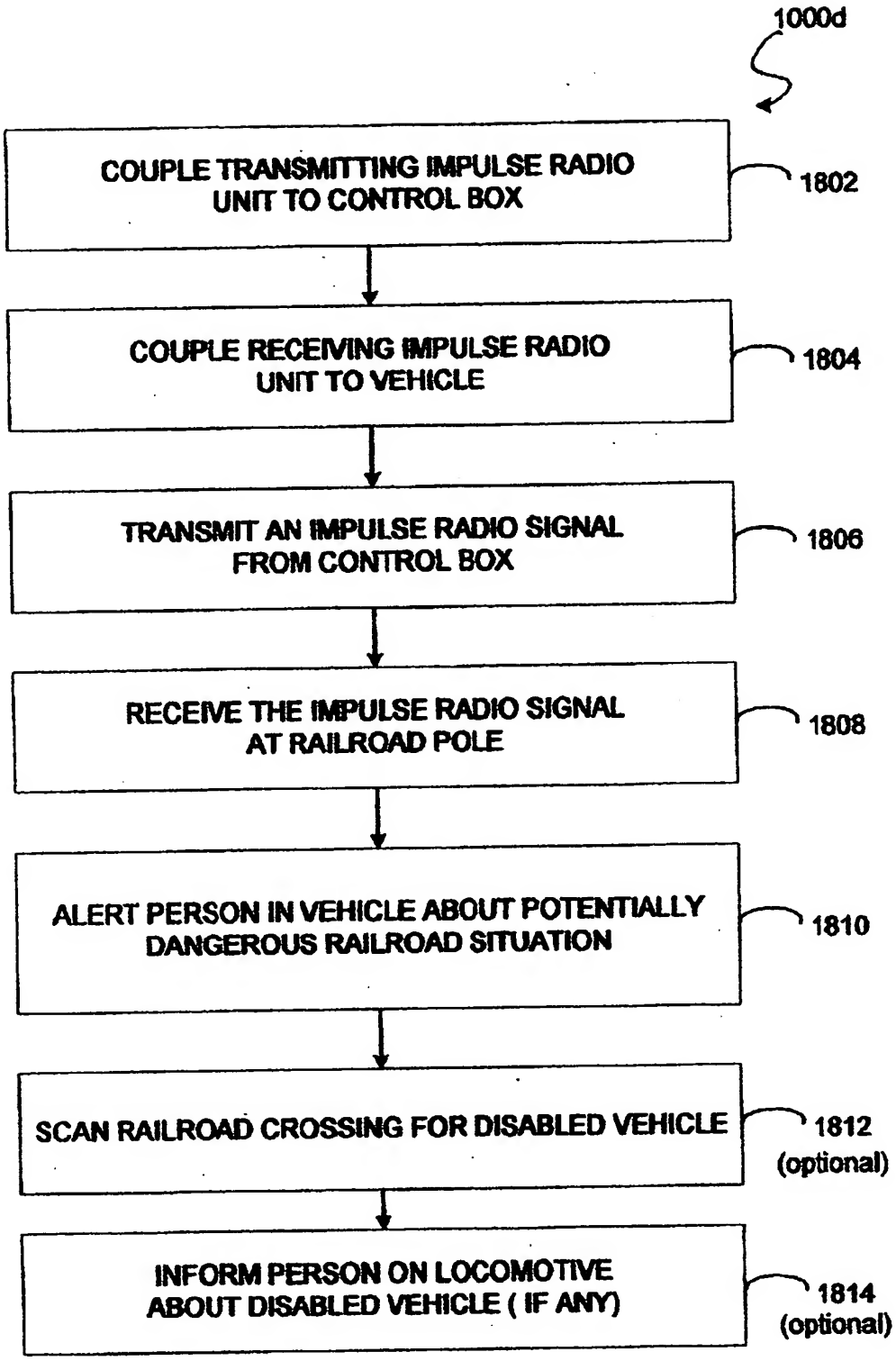

1000d
COUPLE TRANSMITTING IMPULSE RADIO UNIT TO CONTROL BOX
1802
COUPLE RECEIVING IMPULSE RADIO UNIT TO VEHICLE
1804
TRANSMIT AN IMPULSE RADIO SIGNAL FROM CONTROL BOX
1806
RECEIVE THE IMPULSE RADIO SIGNAL AT RAILROAD POLE
1808
ALERT PERSON IN VEHICLE ABOUT POTENTIALLY DANGEROUS RAILROAD SITUATION
1810
SCAN RAILROAD CROSSING FOR DISABLED VEHICLE
1812
(optional)
INFORM PERSON ON LOCOMOTIVE ABOUT DISABLED VEHICLE (IF ANY)
1814
(optional)

FIG. 18

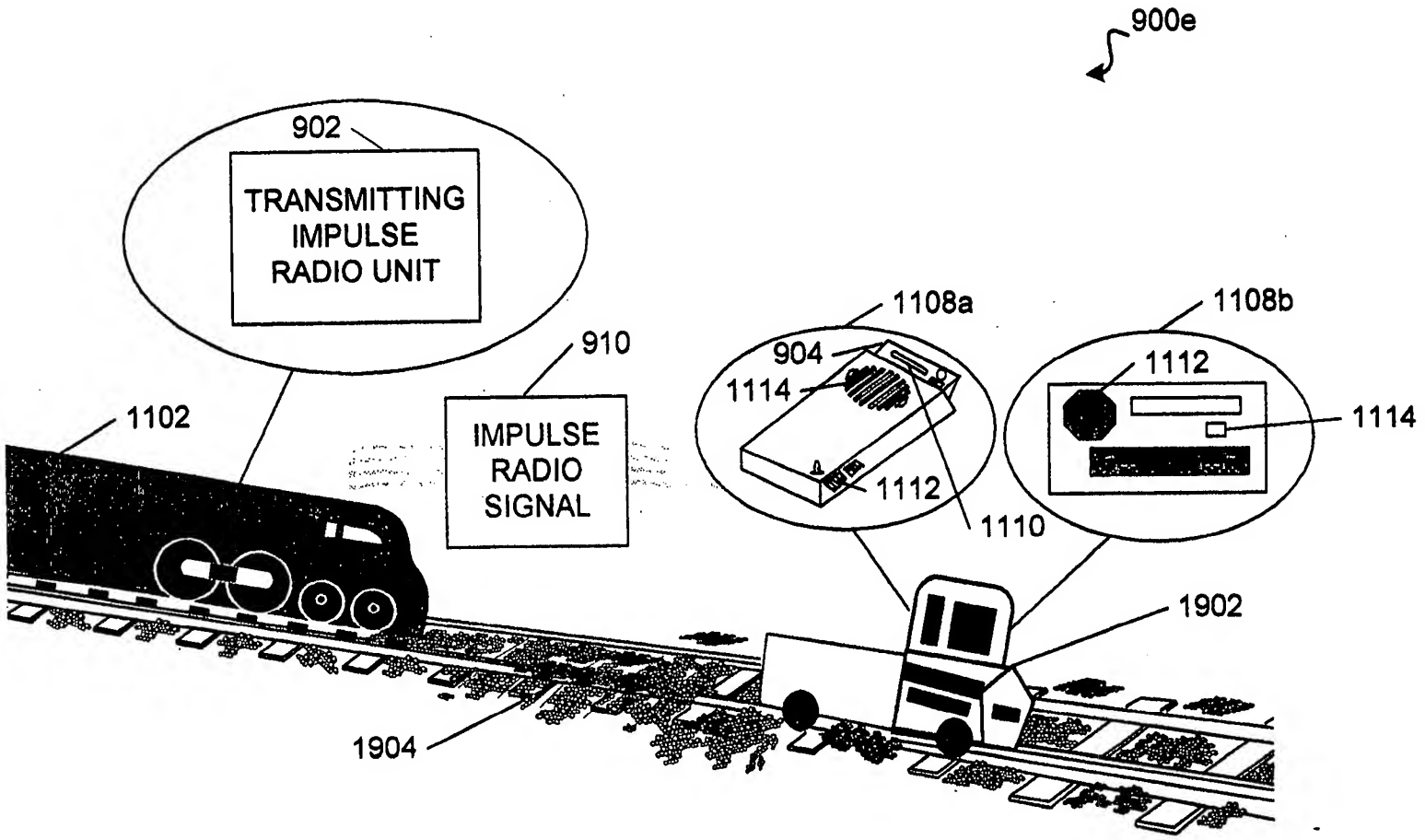

900e
902
TRANSMITTING IMPULSE RADIO UNIT
910
IMPULSE RADIO SIGNAL
1102
1108a
1108b
904
1114
1112
1110
1112
1114
1902
1904

FIG. 19

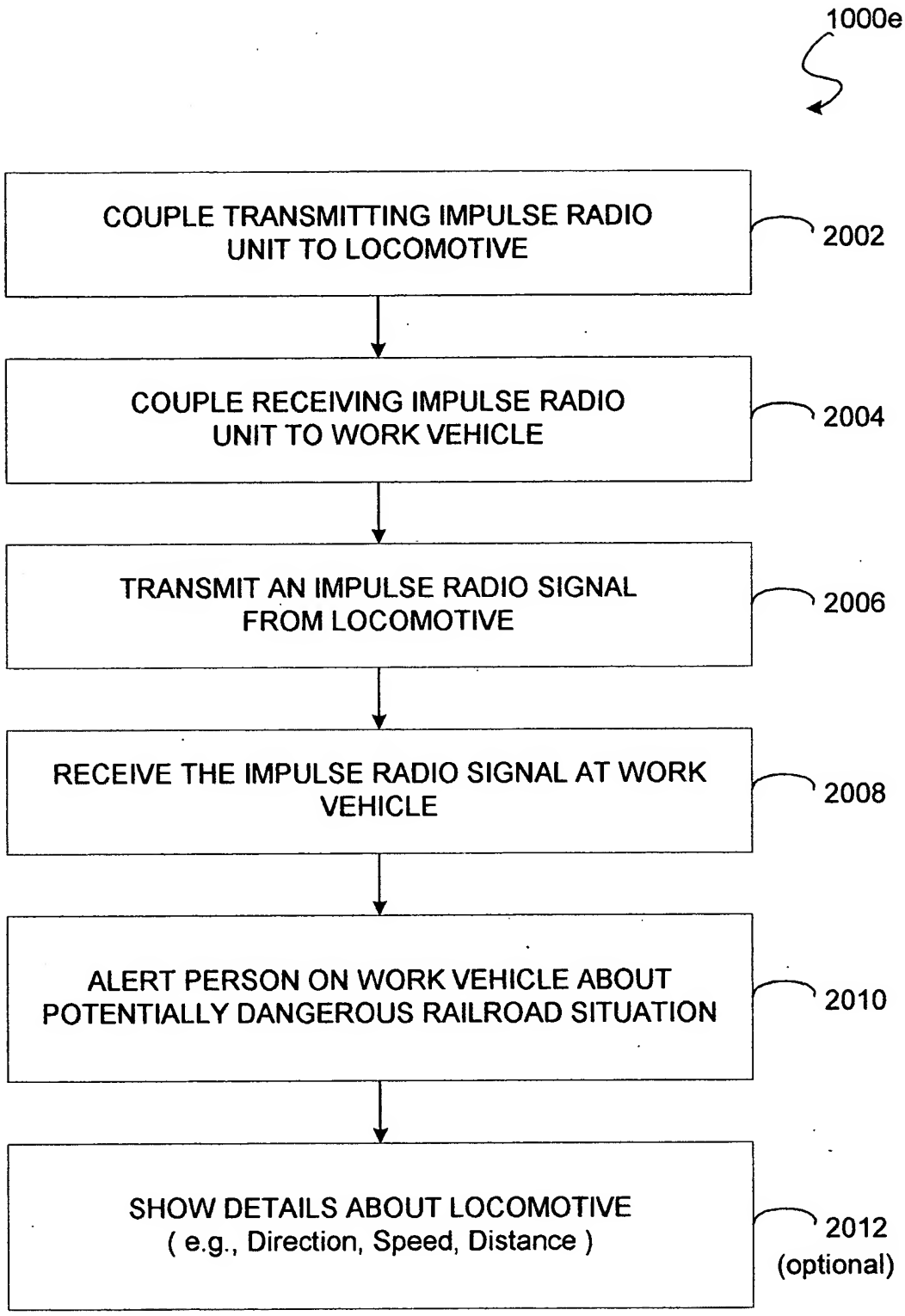

1000e
COUPLE TRANSMITTING IMPULSE RADIO UNIT TO LOCOMOTIVE
2002
COUPLE RECEIVING IMPULSE RADIO UNIT TO WORK VEHICLE
2004
TRANSMIT AN IMPULSE RADIO SIGNAL FROM LOCOMOTIVE
2006
RECEIVE THE IMPULSE RADIO SIGNAL AT WORK VEHICLE
2008
ALERT PERSON ON WORK VEHICLE ABOUT POTENTIALLY DANGEROUS RAILROAD SITUATION
2010
SHOW DETAILS ABOUT LOCOMOTIVE (e.g., Direction, Speed, Distance)
2012 (optional)

FIG. 20

BEST AVAILABLE COPY

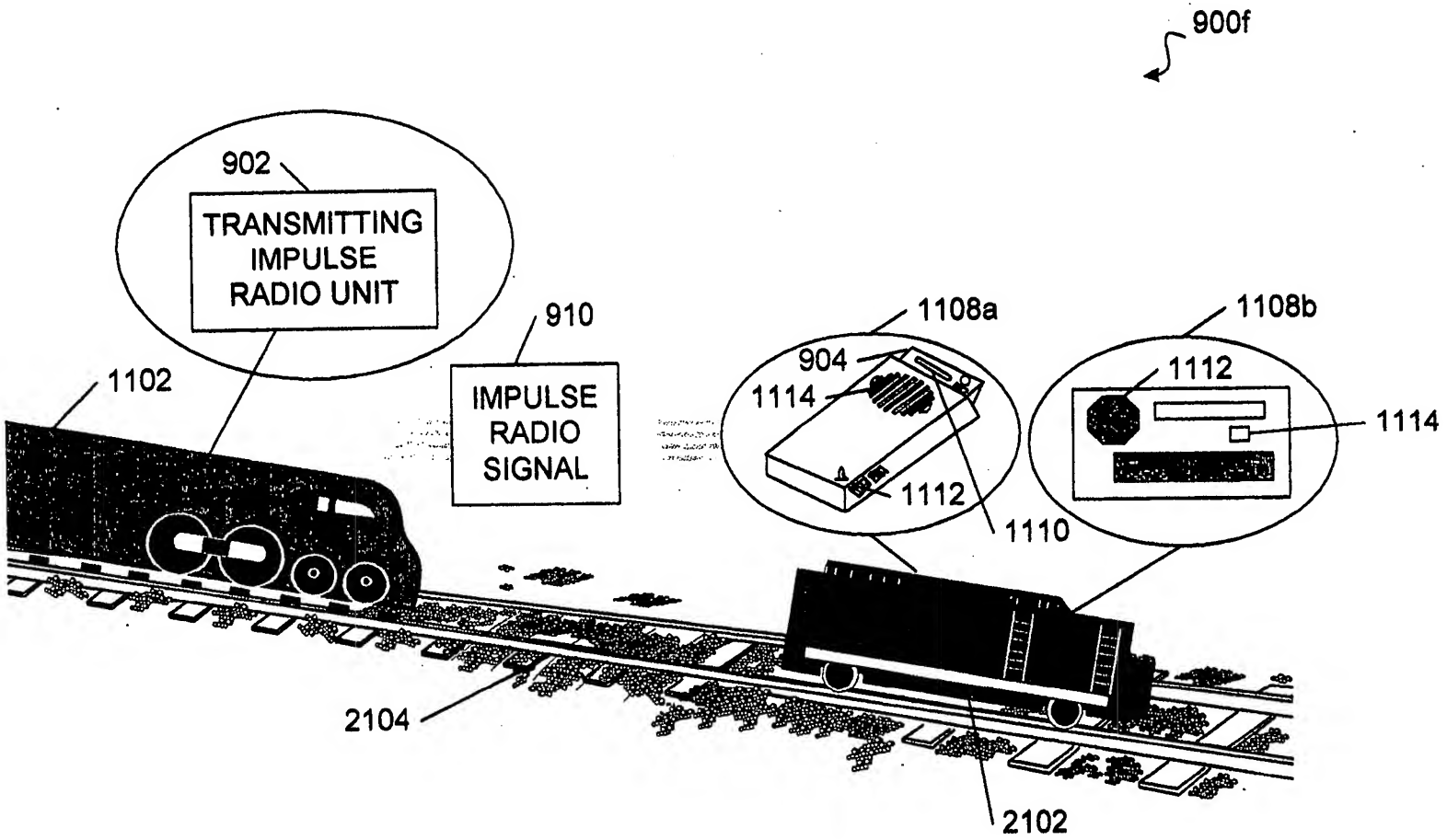


FIG. 21

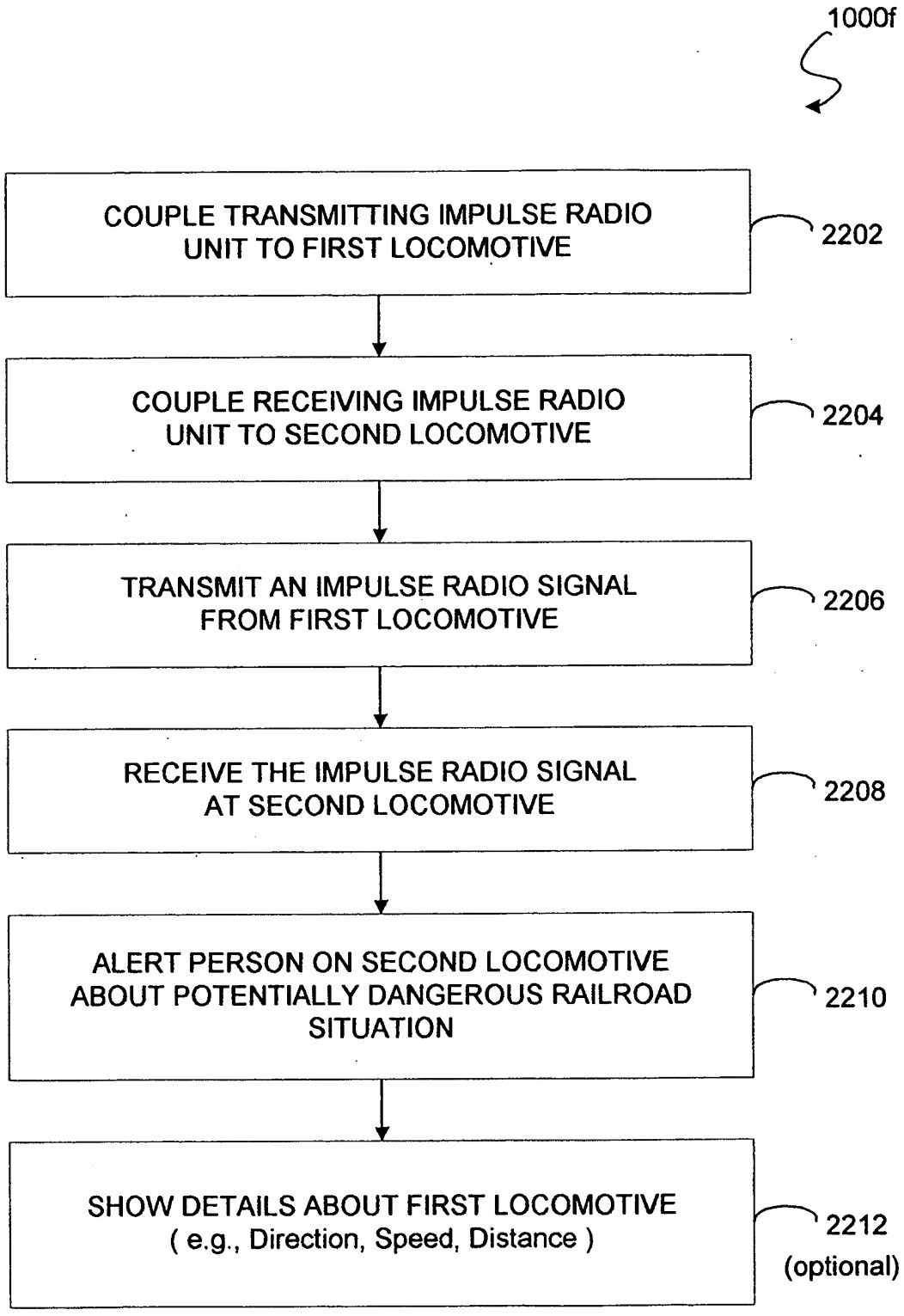

1000f
COUPLE TRANSMITTING IMPULSE RADIO UNIT TO FIRST LOCOMOTIVE
2202
COUPLE RECEIVING IMPULSE RADIO UNIT TO SECOND LOCOMOTIVE
2204
TRANSMIT AN IMPULSE RADIO SIGNAL FROM FIRST LOCOMOTIVE
2206
RECEIVE THE IMPULSE RADIO SIGNAL AT SECOND LOCOMOTIVE
2208
ALERT PERSON ON SECOND LOCOMOTIVE ABOUT POTENTIALLY DANGEROUS RAILROAD SITUATION
2210
SHOW DETAILS ABOUT FIRST LOCOMOTIVE (e.g., Direction, Speed, Distance)
2212
(optional)

FIG. 22